The human respiratory and cardiac systems and how each of these parts affect vent...

Health & Medicine

Introduction

A)Respiratory System

1)Name the parts of the body that make up the respiratory system. Describe each of these parts and the role they play in ventilation

Nasal Passage

This is the route that air enters the body. It is structured as a cavity and is divided by a septum, the posterior section is a perpendicular plate of bone and the anterior is a piece of cartilage which separates each nostril. The roof of the nasal cavity is structured of bone. The floor of the nasal cavity is formed from the roof of the mouth, a hard palate at the front and a soft palate behind which consist of involuntary muscle.

The nose is lined with ciliated columnar epithelium, a mucous covered membrane which contains mucous secreting cells which trap particles of dust and dirt. The cilia move the mucous along towards the throat. The hairs at the front of the nostrils trap large particles and smaller particles of dust and bacteria settle in the mucous before being moved along. The mucous provides a protective role to the underlying epithelium preventing it from drying out.

The projecting conchae, which is divided into three passages the inferior, middle and superior cavities increases the surface area and spreads the area across the whole of the surface of the nasal cavity. This large surface area provides maximum efficiency to warming and filtering of the air. The warming of the air is due to the large amount of blood vessels of the mucosa. As the air travels it passes the mucosa which is moist and it here becomes saturated with water vapour.

Epiglottis

This is flap of cartilage a leaf shaped structure which is fibro elastic cartilage attached to the thyroid cartilage. It is covered in stratified squamous epithelium which swings across the entrance of the larynx. Providing and opening a closing mechanism. The structure is purposeful as it ensures that whilst swallowing the flap stopsfoodand drink from entering the trachea.

Pharynx

The pharynx is a tube which is around 12 cm long. It is positioned behind the mouth nose and the pharynx. Air passes through the larynx through the nasal and oral sections and food only passes through laryngeal sections.

The pharynx is lined in mucous membrane, ciliated columnar epithelium in the nasopharynx. In other regions of the pharynx it is lined with stratified squamous epithelium to protect underlying tissues.

The pharynx has a layer of tissue called sub-mucosa as well as a layer of smooth muscle which help to keep the pharynx open so that breathing is not stopped from happening. The air is warmed by the pharynx as alike the nasal cavity

Larynx

Is made up of several cartilages. These cartilages are all attached to one another by ligaments and various membranes. The thyroid cartilage is the basis of majority of the anterior and posterior walls of the larynx. The epiglottis is attached to the thyroid cartilage. During swallowing the larynx moves upwards and blocks the opening of it from the pharynx. This is where the epiglottis covers the larynx. The larynx provides the link from the pharynx to the trachea. The larynx continues to warm and filter air that passes through.

Trachea

Is a muscular tube approximately 2-2. 5 cm wide. It is made up of three layers of tissue and is held open by with C shaped rings of muscle cartilage. There is soft tissue in between the cartilage which allows flexibility allowing for swallowing. The trachea is lined with ciliated columnar epithelial cells containing goblet cells and mucous glands which cleanse the air and the mucous traps any dust in the inspired air. The cilia of the mucous membrane waft the particles upwards towards the larynx so that they are swallowed or coughed out of the body. The thin walled blood vessels warm the air as it is contact with a warm surface. The zeros glands moisten the air as it passes.

The trachea divides into two to form the bronchi.

Bronchi

The bronchus is a muscular tube which branches into each lung. It forms the branches of the air duct system. The bronchus is smaller in diameter than the trachea. The right bronchus is wider but shorter than the left bronchi and is approximately 2. 5cm long. The left bronchus is approx. 5 cm long and is narrower than the right. The bronchial walls are lined with ciliated columnar epithelium. The role of the bronchus is to regulate both volume and speed of air into and within the lungs. This is controlled by the parasympathetic nerve supply causing constriction and the sympathetic nerve supply causing dilation. The bronchus also continues to humidify and warm air as well as the removal of particles and foreign bodies.

The right bronchus divides into three branches to each lobe before dividing into bronchioles.

The left bronchus divides into two branches to each lobe, and then divides into the bronchioles. The smooth muscle allows the diameter of the airways to increase or decrease due to the nerve supply regulation. The bronchi divide, and their structure changes to match their function. The cartilage rings are present however as the airways divide the rings become smaller. The epithelial lining of the bronchus decreases and is replaced with non-ciliated epithelium.

Bronchioles

Branch off the bronchi, into smaller diameter tubes. They are made up of smooth muscle to ease contraction, and this changes the diameter of the lumen. Each lobule is supplied with air by a terminal bronchiole.

The mucous membrane changes from ciliated columnar epithelium to ciliated simple columnar epithelium with some goblet cells in the larger bronchioles to, no goblet cells and only simple cuboidal epithelium in smaller bronchioles, to non-ciliated simple cuboidal epithelium in the terminal bronchioles. Where there are no cilia present any inhaled particles are removed by macrophages.

The air is conducted and contraction occurs to alter smaller tubes to vary the inflow to and from the respiratory system beyond. The bronchioles branch further to alveolar ducts.

Alveloi

There are thousands (approx. 30 million in adult lungs) of these tiny air sacs in the lungs. The alveoli surround the alveolar ducts. Alveolar ducts are smooth muscular tubes containing alveolar macrophages that engulf foreign matter and end in the alveoli.

There are two types of alveolar cells, type I are one cell thick are lined with simple squamous epithelial cells which line and cover the structure. Alveolar type II are also referred to as septal cells. And are placed between type I alveolar cells. Each alveolar sac consists of two alveoli. Type I alveolar cells are where gas exchange takes place. The type II cells contain microvilli which ensure the surfaces between cells are moist.

The vast surface area of the alveoli provides an idealenvironmentfor diffusion to occur rapidly through the walls of alveoli and the blood. As well as being one cell tick means that the diffusion is able to take place at great speed as they only have once layer equalling a smaller distance to diffuse through.

Over 80% of the surface area of the alveoli is covered in capillaries which allow the haemoglobin in the red blood cells to pick up and drop off oxygen and carbon dioxide effectively. CO_2 diffuses out as the O_2 is picked up in the red blood cells.

2)Explain how the cells of the alveoli have become specialised

The alveoli contain two types of specialised cells as well as alveolar macrophages. The alveoli are a group of epithelial cells that make up a tissue and carry out specific, specialised roles within the respiratory system and without them gas exchange would not be able to take place.

Type I alveolar cells are flat squamous epithelial cells and form the alveolar wall. Gas exchange takes place through the cell membranes and cytoplasm of the alveolar wall. Alveolar type I cells cover 95%% of the alveolar surface.

Type II alveolar cells are cuboidal septal cells. They are mixed about with the Type I cells and are the remaining 5% of the surface of the alveoli. These cells secrete a phospholipid substance called surfactant, a fluid which coats the inner surface of the alveoli and keep them moist whilst controlling fluid levels. This reduces the surface tension of the pulmonary fluids and allows gas exchange to take place, and prevents the collapse of the air ways.

Alveolar Macrophages

Kill bacteria and trap particles. These cells can also transport indigestible substances to the lymph nodes of the lungs to then be exhaled or coughed out of the body.

3)Evaluate whether effective gaseous exchange has been achieved in humans

The large surface area of the alveoli provides the optimum area for gas exchange to take place. The thin epithelium layer separating the air in the alveoli from the blood in the capillaries provides a short travelling distance for the diffusion of gases to take place. The blood in the capillaries lining the alveoli are removing oxygen all of the time. The oxygen concentration is kept low therefore the steep concentration gradient is maintained. The relationship of diffusion is described by:

Fick's law: Rate = surface area x difference in concentration

Thickness

For diffusion to be efficient the surface area and concentration difference should be as high as possible and the length and thickness of the pathway as low as possible. The thinner the membrane, the faster the diffusion.

In the human body an effective gaseous exchange process has been achieved as the concentration difference is maintained as the blood is continually pumped around the body, therefore the blood passing through the capillaries are picking up oxygen from the alveoli and living behind carbon dioxide. The surface area of the alveoli being thin and vast allows the oxygen to pass through at speed.

4)Explain the role of the nervous system in controlling breathing

Overall control of the respiratory system is by the respiratory centre in the brain which is involuntary. The respiratory muscles require on-going neutral stimuli to function. The muscles contract, changing the size of the thorax, which increases the volume inside the thoracic cavity. This reduces air pressure and the air rushes into the lungs. This stimulates the stretch receptors in the walls of the bronchus. The messages are then returned to the brain by the vagus nerve.

This is due to the nerve impulses being transmitted from the respiratory centre, a cluster of neurons in the brain (medulla oblongata and the pons of the brain stem). When these impulses reach the diaphragm and the intercostal muscles they contract in inhalation takes place. When there are no nerve impulses the muscles relax for a short resting period and the cycle then repeats. When the lungs are fully inflated due to inspiration the pause in the signal causes the lungs to deflate and expiration takes place.

There are chemoreceptors which are responsible for detecting changes and they are present in the wall of the aorta, the carotid bodies and the medulla oblongata. The central chemoreceptors which are present in the medulla oblongata detect rises of carbon dioxide and stimulate the respiratory centre, increasing the ventilation of the lungs and reducing the arterial partial pressure of co2. The chemoreceptors respond to changes in the partial pressure in oxygen and the levels of carbon dioxide in the blood. The activity of the respiratory centre is adjusted by the nerves in the pons in response to input from other parts of the brain. The inspiration neurons set the rate and the depth of breathing. The axons of the sensory neurons from the aortic bodies are part of the vagus nerve. The peripheral chemoreceptors are conveyed by the vagus nerve to the medulla and stimulate the respiratory centre, the rate and depth of breathing are then increased and the increase in blood pH level stimulates the peripheral chemoreceptors increasing ventilation, in turn increases carbon dioxide causing an increase in the blood pH levels.

B)BLOOD

1)Name 5 components of blood plasma and describe their functions

Different sections of plasma contain a different composition. Plasma is made up of 90% water and 10 % dry matter.

Plasma is made up of around 7% of plasma proteins. Which are responsible for the osmotic pressure of bloodIf the plasma proteins fall the osmotic pressure will be reduced and the fluid will move into the tissues. The thickness of plasma is also due to the plasma proteins such as albumin and fibrinogen.

Albumin- provides the osmotic balance and pressure. The albumins are carriers for free fatty acids.

Globulins- have several roles in the plasma. They act as immunoglobulins which are complex proteins. They neutralise antigens by binding to them. They also transport some hormones and mineral salts as well as providing inhabitation of some enzymes.

Salts- assist in the osmotic balance and the conduction of nerve impulses. Assist With blood clotting as well as transporting CO2.

Electrolytes- Have various roles within the plasma including the transmission of nerve impulses as well as muscle contraction and the maintenance of maintaining the pH level of blood.

Gases- Are transported around the body in the plasma as dissolved substances. Most of the carbon dioxide in the body is transported as bicarbonate ions in the plasma.

Hormones- Hormones pass into the blood directly from the endocrine cells. The blood transports them to the area of the body where they are required for cellular activity.

Heat in the plasma is to maintain static core body temperature. Oxygen in the plasma is required for the aerobic respiration in the cells and Waste products such as urea serve no purpose as they are the waste products of protein metabolism. Urea is transported in the blood to the kidneys to be excreted.

2)How does the unusual shape of the red blood cell improve its function?

Red blood cells are approx. 7 micrometres in diameter they have no nucleus and no intracellular organelles meaning there is more room for haemoglobin to be present in the red blood cell rather than in solution, which is responsible for gas exchange. The bio concave disc shape of the red blood cell raises the surface and cytoplasmic volume ratio. Allowing vast volume and a large surface area provides the ideal environment for diffusion of gaseous exchange.

The red blood cells are packed with chemicals and enzymes which allow haemoglobin to carry oxygen effectively. The biconcave discs, the thinness of their central area allows unloading and loading of oxygen easier.

The selectively permeable membrane makes them flexible and smooth allowing them to squeeze through capillaries making gaseous exchange more efficient. All of the haemoglobin that cells contain is close to the surface which is also a contributing factor for exchange of gases being able to take place with ease as this lessens the distance to be travelled.

The red blood cells respire aerobically so they do not use of the oxygen that they are carrying.

Antigens on the surface of the red blood cells enabling the blood type to be defined.

3)How is oxygen transported around the body?

Oxygen is carried around the body in two ways, 98% in the red blood cells, 2% dissolved in the blood plasma. Once air is breathed in, it enters the lungs via the trachea, bronchi, bronchioles and into the alveoli. The oxygen is diffused into the red blood cells through the walls of the alveoli and the oxygen combines with the haemoglobin in the red blood cells and is transported through the capillaries.

The alveoli contain high levels of oxygen therefore diffuses into the blood cells which are low in oxygen as it is deoxygenated blood from the lungs and the concentration difference can be maintained as blood is continually pumped around the body, therefore fresh blood is passing through the capillaries picking up oxygen from the alveoli.

Once a red blood cell has picked up the oxygen the enzyme carbonic acid makes Hb molecule less stable which makes them release the oxygen molecules. The oxygen can then diffuse into the cells where it is required.

The haemoglobin present in the red blood cells is made up of 4 peptide chains, each of which contains one haem group. The polypeptide chains hold the haem group in place and help to upload oxygen. Each haem group combines with one oxygen molecule. The haemoglobin binds to the oxygen and releases it when the concentration falls. When all four of the oxygen binding sites are full, the haemoglobin molecule is described as saturated.

When the first molecule of oxygen binds to the haemoglobin in the red blood cells it changes the shape of the haemoglobin making it easier for the rest of the molecules to bind. The pressure from the dissolved oxygen in the plasma helps the oxygen at its binding site. Haemoglobin binds reversibly to oxygen and forms oxyhaemoglobin.

The oxygen is bound loosely to the haemoglobin and so when the oxygen is required it can be released with speed.

When there is a low pH level in places such as exercising muscles the oxyhaemoglobin breaks down providing the additional oxygen for use by the tissues.

When no oxygen is present, none of the haem will be carrying oxygen. When partial pressure of oxygen is at its highest this is when the haem is saturated with oxygen. When the blood flows through the capillaries in the lungs the haem is converted into haemoglobin at speed to supply the respiring tissues.

OXYHAEMOGLOBIN DISSOCIATION CURVE

Image ref: http://www. zuniv. net/physiology/book/chapter15. html

The ability of haemoglobin to transport oxygen is affected by the amount of carbon dioxide present. The lungs have a high partial pressure of O2 and a low partial pressure of CO2 In the lungs the more CO2, the oxygen dissociation curve is moved to the right this is known as the BOHR shift. This is due CO2 being removed from the body, here in the lungs.

The tissues are low in partial pressure of oxygen and are high in partial pressure of CO2 as the CO2 is being produced as a result of respiration; this is why the RBC needs to deliver more oxygen to the respiring tissues.

4)How is carbon dioxide transported around the body?

Carbon dioxide travels in the red blood cells and in blood plasma. The largest fraction 23% of Carbon dioxide travels in the red blood cells as carbaminohaemoglobin (CO2-H6) It binds with the amino groups of amino acids and proteins, by binding to the peptide chains of the plasma proteins in the blood to form carbamino compounds. 70% travels as bicarbonate ions in the plasma (HCO-3)

7% of carbon dioxide is dissolved in blood plasma as CO3 which is a bicarbonate ion.

The CO_2 binds to haemoglobin and creates $Hb\text{-}Co_2$, carbamino haemoglobin, by binding to the polypeptide chains of the haemoglobin molecule.

Carbon dioxide is much more soluble in the blood than oxygen is, and there is 4ml of CO_2 to every 100 ml of blood.

Carbon dioxide enters the red blood cells and combines with hydrogen and forms carbonic acid. The carbonic acid splits into a hydrogen ion (H^+) and a bicarbonate ion (HCO_3) the enzyme carbonic anhydrase in the red blood cells speeds up the process. The hydrogen ions formed from the dissociated carbonic acid then combines with the haemoglobin in the red blood cells and this makes the haemoglobin less stable in the red blood cell and it causes it to release oxygen. The carbonic acid is then broken down into CO_2 and water and the $HC0_3$ in the red blood cell diffuses out into the blood plasma. Once the gathered hydrogen carbonate ions diffuse out into the plasma, this gives the red blood cell a positive charge. Chloride ions (cl^-) present in the blood plasma diffuse into the red blood cells from the plasma to maintain a neutral charge; this is known as the chloride shift. The hydrogen ions are taken up by buffers in the plasma and the haemoglobin acts as a buffer in the red blood cells.

The lifecycle of the carbon dioxide molecule is to diffuse from respiring tissues through the capillary walls and plasma into the red blood cells to then be diffused into the alveoli to be exhaled.

Carbon dioxide levels vary in proportion to how much the body is being exerted. The harder a person exercise the greater the level of carbon dioxide that will be present.

*The diagram above represents my interpretation of the life cycle of carbon dioxide molecule within tissues, plasma and red blood cells

5)A group of muscle cells are respiring faster than usual as they work harder. Explain what affect this will have on the ability of the blood to carry oxygen and why?

During exercise, CO2 diffuses from the respiring cells in the tissues into the red blood cells. Oxygen is required to make ATP, and carbon dioxide is produced as a bi-product of this. As the energy is made the cells in the muscle tissues have a higher concentration of CO2. This CO2 then makes the haemoglobin less stable and it releases more oxygen known as the Bohr Effect. As the muscles are working harder they are respiring faster increasing the requirement of oxygen supply and the concentration of oxygen will be low.

During exercise muscles are working harder and respiring faster, and therefore require more oxygen. More oxygen is removed from the red blood cells to supply the muscle tissues, therefore creating a decrease in the oxygen concentration levels and partial pressure. ‘’Henry’s law states that the quantity of a gas that will dissolve in a liquid is proportional to the partial pressure of the gas and its solubility’’… (Tortora &Dickenson p897). The blood flow through the capillaries increase, forcing the lumen of the veins to expand so that the volume of blood can enter the heart faster, as due to exercise the heart rate will also increase and will be pumping blood at a faster rate than that of at rest.

The oxygen will diffuse from an area of high concentration in this case the alveoli to an area of low concentration, during exercise this will be in the respiring tissues.

During exercise the blood flow will be focused on supplying the muscles that require the oxygen rather than other areas of the body.

Exhalation takes place when the body is forcefully breathing such as during exercise.

The myoglobin in mammalian muscles can pick up oxygen from the haemoglobin and store it until it is needed. The respiring cells in the tissues needed oxygen to make the ATP. The ability of the haemoglobin to transport oxygen is affected by the amount of carbon dioxide present. The tissues have a low partial pressure of oxygen, and high partial pressure levels of carbon dioxide as this is where the carbon dioxide is being produced as a result of respiration.

C) Circulatory System

1)Compare the structure of a capillary, vein and an artery and explain why their structures allow them to carry out their specific functions.

Arteries vary in size; they have three layers of tissue. Tunica adventitia which is the outer layer of fibrous tissue, Tunic Media which is the middle layer of smooth muscle and elastic tissue and Tunica intima which is the inner lining of squamous epithelium called endothelium.

This allows the vessel walls to stretch, absorbing pressure which is generated by the heart. As the arteries branch they become smaller, so in the arterioles (the smallest artery) the tunica media is mainly made up of smooth muscle. This enables the diameter to be controlled and regulates the pressure of the blood.

Arteries in comparison to veins have thicker walls so that they can handle the high pressure of the arteriole blood.

The sympathetic fibres of the autonomic nervous system kick start the smooth muscle of the blood vessels which increases and stimulates the smooth muscle to contract. This squeezing narrows the vessel wall and narrowing the lumen which is known as vasoconstriction. When the sympathetic stimulation decreases the smooth muscles relax, the lumen increases in diameter and this is known as vasodilation.

The elastic arteries are the biggest in the body; they propel blood onwards whilst the ventricles relax.

The walls stretch as blood as passed from the heart into the elastic arteries and they can house the surge of blood. They take the blood away from the heart.

In comparison to the veins which return the blood to the heart, therefore have thin walls. They do have the same three layers of tissue that the arteries have, however being thinner they have less muscle and elastic tissue in the tunica media as the veins carry blood at a low pressure. Some vein having valves which prevents a backflow of blood, ensuring the blood is directed to the heart. Within the tunica media of the heart is a fold which is strengthened by connective tissue.

The veins have a large capacity to hold blood, if there is a haemorrhage this give the veins the opportunity to recoil and can help to stop a sudden fall in blood pressure.

The smooth muscle which is present in both the veins and the arteries of the tunica media is supplied by the nerves of the autonomic nervous system in the medulla oblongata. These nerves pass signals to change the diameter of the lumen, and this controls the amount of blood they can contain.

Muscular arteries distribute blood to the organs, the tunica media is thicker than the tunica media in other types of arteries as they need to contract and maintain the partial contraction and vascular tone. This can stiffen the vessel wall. This ensures the pressure is maintained and efficient blood flow ensues. Arterioles being the smallest arteries regulate the blood flow from the arteries into the capillaries by regulating resistance. The diameter is smaller and so the friction is greater creating more resistance, and this maintains the correct level and pressure of blood flow.

Capillaries vary in diameter. Capillaries are approx. 5-10um, post capillary venules are (10-50um) and muscular venules are 50-200 um. In comparison to veins which are 0. 5um – 3cm) the smallest arteries (arterioles are 15-30um in size.

The tunica interna in the elastic arteries are well defined elastic lamina within the elastic arteries and the muscular arteries, however in the arterioles are thin. In the capillaries, and post capillary venules there us just an endothelium and basement membrane. This is suited to their function for exchanges of products, as the short distance provides an optimum environment for diffusion. Within the veins there is endothelium and basement membrane with no internal elastic lamina, they do however contain valves, and the lumen is larger than that of arteries. Blood pressure is at its highest in the large arteries and the blood pressure decreases as it passes through the smaller arterioles and into the capillaries. The capillaries having the largest surface area, being thin and permeable allowing for fast diffusion and exchange of products.

The tunica media in the arteries is a thick layer, mainly made of smooth muscle this sis to withstand the pulses of blood at a high pressure.

The smooth muscle in the arterioles provides a pre capillary sphincter. This is in contrast to the capillaries which do not have a tunica media layer. The veins have no elastic lamina and carry slower flowing blood at low pressure compared to both the capillaries and the arteries.

The Tunica externa varies in the arteries, in the elastic arteries the tunica externa is thinner than the tunica media and in the muscular arteries it is thicker than the tunica media. In the arterioles this is a loose connective tissue layer made up of sympathetic nerves.

The capillaries do not have this layer, as their role is to be permeable to exchange materials between blood and nearby cells. Within the veins this layer is the thickest of the three layers.

The elastic arteries are composed to conduct blood to the heart and the muscular arteries. The muscular arteries distribute blood to the arterioles and the arterioles in turn supply and regulate blood flow to the capillaries. The capillaries are thin and leaky as they have the role of allowing the exchange of products as mentioned above. They also distribute blood to the post capillary venules which pass blood to the muscular venules. This is where the exchange of nutrients, waste and interstitial fluid takes place. The muscular venules pass blood to the veins and accumulate large volumes of blood. The veins return the blood to the heart and to the veins in the limbs.

Therefore the capillary although having a vast surface area, is the thinnest in comparison to veins and arteries which both have the same tissue layers.

The arteries and the veins have varying degrees of thickness of these tissues to allow their role to be performed effectively.

2)Compare the structure of the atria and the ventricles in the heart.

The heart has four chambers; the two superior chambers are the atria. They are the receiving chambers of the heart. The two inferior chambers are the ventricles. They are the pumping section of the heart. The atria are a pouch like structure called an auricle and they increase the capacity of the atrium so that it can hold a greater volume of blood. The right atrium receives blood from the three veins, the superior vena cava, the inferior vena cava and the coronary sinus. The right atrium forms the right border of the heart, the blood passes from the right atrium to the right ventricle through the tricuspid valve. The cusps of the tricuspid valves are connected to tendon like cords

Chordae tendinae which are connected to cone shaped trabeculae called papillary muscles.

The coronary sulcus is the boundary between the atria and the ventricles. In between the right and left atria is a partition called interatrial septum. The interventricular septum divides the right and left ventricles.

The right ventricle is 4-5mm in thickness and forms most of the anterior surface of the heart. Inside the right ventricle is a series of ridges formed by raised bundles of cardiac muscle fibres called vabeule carnae. The right atria in comparison are 2-3mm in thickness and have a smooth posterior wall and a rough anterior wall which is formed by muscular ridges called pectinate muscles.

The left atria and the right atria form the base of the heart; they receive blood from the lungs through the pulmonary veins.

The left atria allow blood flow to the left ventricle through the mitral valve. The atrium have thin walls as they deliver blood at a lower pressure in comparison to the ventricles which pump blood at a high pressure and through a greater distance and therefore have thicker walls to withstand the pressure.

The left ventricle is the thickest chamber of the heart and is approx. 10-15mm. It forms the apex of the heart. Alike the right ventricle is contains trabeculae carnae and has chordae tendinae. The blood passes from the left ventricle to the aortic valve.

The right ventricle has a smaller workload and pumps blood a shorter distance to the lungs at a lower pressure. The right and left ventricles are two separate pumps, which simultaneously eject equal volumes of blood to the lungs and the rest of the body. However the left ventricle pumps blood a longer distance and so the flow is larger, and needs to maintain the same rate of blood flow as that of the right ventricle, this is why the muscular wall is thicker in the left ventricle.

The perimeter of the lumen space of the left ventricle is circular in comparison the lumen on the right ventricle which is crescent shaped.

The pulmonary veins from each lung carry oxygenated blood back to the left atria and this passes to the left ventricle valve into the left ventricle which is then pumped to the aorta.

3)Describe the four stages that make up on single heartbeat

A cardiac cycle is one heartbeat. In each cycle the atria and ventricles alternately contract and relax. This forces blood from an area of high pressure to low pressure. As a chamber of the heart contracts, the blood pressure increases, when cardiac muscle contracts this also causes blood pressure to increase and the blood is then forced out of the atria to the ventricles.

Each heartbeat creates 75cm3 of blood, this has to be pumped from each ventricle and this is the stroke volume. Each cardiac cycle takes approx. 0. 8 seconds.

The Sino atrial node (SAN) begins a single heartbeat. The Atrio ventricular node node picks up the signal and channels it down the middle of the ventricular septum through the cardiac muscle fibres (His).

This signal then spreads throughout the wall of the ventricles through the Purkyne fibres and this stimulates the ventricles to contract, once they have filled with blood.

Arterial systole begins when the SAN sends a message causing atrial depolarisation. This takes approx. 0. 1 second. The atria begin contracting and during this time the ventricles are relaxed. As the atria fill with blood from the vena cava and the pulmonary vein, the atrium apply pressure to the blood they contain, forcing the blood through the open AV valves and into the ventricles. Once the atria have stopped contracting, the ventricles cease relaxation.

Ventricular systole lasts approx. 0. 3 seconds. This is the stage of ventricular contraction. The AVN picks up the signal from the SAN and conducts the impulses which causes depolarisation and stimulates the ventricles to contract, and forcing the blood upwards. This ventricular depolarisation begins ventricular systole. The pressure rises in the ventricles and blood is pushed up against the AV valves forcing them to close. The semi lunar valves are also closed and this is isovolumetric contraction. During this time the cardiac muscle fibres contract and apply force. The ventricular volume remains the same (isovolumic). The contraction of the ventricles causes pressure to rise at a heightened level.

When the right ventricle pressure is above the pressure of the pulmonary trunk the semi lunar valves open and the ejection of blood from the heart begins. The pressure in the left ventricles continues to rise to approx. 120mmHg whereas the right ventricle is 25-30mmHg. The left ventricle passes around 70ml of blood into the aorta and the right ventricle ejects the equal amount to the pulmonary trunk.

The volume that is remaining in the ventricles at the end of the systole is the end systolic volume (the stroke volume)

Atrial Diastole lasts approx. 0. 7 seconds, and is when the atria relax, this overlaps with other stages of the heartbeat. Whilst the ventricles are still in contraction, the atria begin to fill with blood from the vena cava and the pulmonary artery.

The atria and the ventricles both have periods of relaxation however as the heart beat gets faster the relaxation period gets shorter.

Ventricular Diastole is a relaxation period which lasts approx. 0. 4 seconds. The ventricular depolarisation causes ventricular diastole. When the pressure in the chambers of the heart falls and the blood present in the aorta and pulmonary trunk flows back to regions of low pressure in the ventricles, the back flowing blood enters the valve cusps and closes the semi lunar valves. As the ventricles relax the pressure falls at a fast rate, when the pressure falls below that of the atrial pressure the atria fill will with blood and the blood flows from the atria to the ventricles which forces the AV valves to open again.

4)If the Sino atrial node is stimulated it triggers a wave of contractions through the heart. How does that process ensure that the atria contract together and ventricles contract from the bottom upwards?

The SAN signals spread across the walls of the atria causing a contraction. This signal does not pass directly to the ventricles ensuring that the ventricles do not contract as they are not filled with blood. The AVN picks up the impulses and channels them through the bundle of His. The signal is delayed slightly and then and then spreads through the walls of the ventricles. Once they are filled will blood the ventricles can then contract.

The ventricles contract from the base upwards ensuring blood is forced up, forcing the AV valves to shut and the semi lunar valves to open. The blood leaves the heart out of the vessels at high pressure, leaving the chambers at the top of the heart with great speed.

Why do the atria contract together?

5)An athlete is training for a big competition

Part 1

The table (attached) shows the blood flow seen in the athlete's body at rest and during training. Explain the distribution of blood before and after exercise in the organs listed.

& Part 2 b) Explain how an increase in carbon dioxide when exercising will increase the cardiac output and the rate of ventilation of the athlete

*A flow chart showing factors which effect blood flow during exercise

Image ref: http://www. biosbcc. net/doohan/sample/htm/COandMAPhtm. htm

The volume of blood pumped by the heart is the stroke volume, on average 80cm3 is supplied at rest and this increases to 1100cm3 during exercise.

During exercise the blood vessels in the muscles dilate as ATP is used up in the working muscles. The muscles work harder and respire faster, this causes more oxygen to be released from the red blood cells, creating a decrease in the partial pressure and creates products such as carbon dioxide are produced and diffuse from the muscle cells. This lowers the pH levels in the blood. The chemoreceptors detect this and the respiratory centre responds by increasing the heart rate and the ventilation rate.

The capillaries to expand and dilate, as the blood flow increases and more oxygenated blood is supplied to the muscles that require it. The gaseous exchange increases, decreasing the output of blood to other organs.

Respiring cells in the tissues have a higher level of carbon dioxide concentration as the energy is being made, and this makes the haemoglobin release more oxygen. As the carbon dioxide rises the nervous impulses from the respiratory centre cause the diaphragm to contract increasing the rate of inspiration of air into the lungs.

Prolonged periods of using the muscles increases the cardiac output and this increases the rate of ventilation, the rate and force of the heart beat and this matches the body’s needs to bring more oxygen to the cells and remove more of the carbon dioxide that is being produced.

The heart is pumping faster during exercise and therefore needs a higher level of blood supply to meet demand at a faster rate. During rest the heart is still working however not at such an intense level as during exercise. The brain is always supplied with the same amount of blood and is never starved regardless of the body's activities.

The muscles require more blood when they are working than when they are at rest. Therefore the organs which require oxygen are prioritised.

The kidneys are not being worked harder during exercise and so the blood supply that they would receive when the body is at rest is higher than that when the body is exercising. The body supplies to meet demand and at the time of exercise, the muscles and the heart require the oxygen rather than the kidneys and other organs not involved in respiration.

Once muscle contraction ceases the oxygen consumption remains above resting levels for a short period of time and this oxygen debt is the added oxygen that remains after the resting period.

As the heart and muscles have been working harder, the body temperature increases due to the ATP which is being produced, the body pushes the blood to the surface of the skin surface increasing the diameter of the blood vessels carrying the blood. (Peripheral vasodilation)

Part 2

a)Calculate the change in cardiac output when the athlete trains

Calculation

At rest: 69 cm3 Divided by 1000 x 71 beats per min = 4. 89 lpm (litres per minute)

During training 178 cm 3 divided by 1000 (0. 178) x 162 beats per min = 28. 8lpm (litres per min.)

C)What effect will exercise have on the athletes pulse rate and why?

After exercise the pulse rate has an initial fall and then a slow return to its normal rate. The resting pulse is 60 for a trained athlete. When exercise begins the oxygen demand is greater than the supply, therefore there is a build-up in the oxygen debt.

The pulse rate and ventilation rate remains higher than normal after a period of exercise as extra oxygen is needed to replace ATP and carbon dioxide stores and oxidise the lactate acid which has accumulated as a bi product during exercise.

The pulse rate increases as exercise starts and reaches a period of oxygen debt at around 90 to 150 there is then a plateau for around 5-6 minutes and then a drop at beginning resting to around 140 and then levels back to approx. 60 at complete rest.

References

Baker, M. Indge, B. & Rowland, M. (2001)Further Studies in Biology. Cambridge: Hodder and Staughton

Blood Gas transport, New human physiology[online] Available from: http://www. zuniv. net/physiology/book/chapter15. html [accessed 19/4/2011]

Boyle, M. & Senior, K (2008)Human Biology Third EditionHammersmith: Harper Collins Ltd

Cardiac output and blood pressure, Biological Sciences, Biomed 108, Human physiology[online] available from: http://www. biosbcc. net/doohan/sample/htm/COandMAPhtm. htm [accessed 22/4/2011]

Hanson, M. (1999)Perspectives in advanced Biology, Cambridge,: Hodder and Staughton

Tortora, G, J. & Derrickson, B, H., 12th edition, (2009)Principles of Anatomy and Physiology, maintenance and continuity of the human body, Volume 1 (s. l.): John Wiley & Sons (Asia) Pte Ltd

Tortora, G, J. & Derrickson, B, H., 12th edition, (2009)Principles of Anatomy and Physiology, maintenance and continuity of the human body, Volume 2 (s. l.): John Wiley & Sons (Asia) Pte Ltd

Waugh, A. & Grant, A., 11th edition, (2010)Ross and Wilson Anatomy and Physiology inhealthand illness.(s. l): Churchill Livingston Elsevier